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Fishery Leaflet 351

Washington 25, D. C. October 1950

TUNA TROLLING IN THE LINE ISLANDS IN THE LATE SPRING OF 1950

By Donald H. Bates Jr.*

INTRODUCTION

The Pacific Oceanic Fishery Investigations research vessel, JOHN R. MANNING, operating out of Honolulu, conducted a two-month survey in the Line Islands during the late spring of 1950 to ascertain the abundance and availability of Line Island tunas to West Coast purse seine equipment. T. J. Roseberry was senior POFI observer aboard, assisted by John E. Rawlings and the writer. Master of the MANNING was Mr. Anton Kursar.

In the normal course of scouting for suitable purse seine schools, 5 to 7 lines were trolled from the MANNING as a secondary and incidental procedure. However, the indications of possible good production of tunas with surface trolling, and the experience gained in surface trolling methods for Line Island tunas, warrants special discussion.

The Line Islands (Kingman Reef, Palmyra, Washington, Fanning, and Christmas, Figure 1) were chosen for this exploratory voyage primarily because they lie within the region of the Equatorial Countercurrent. This current flows eastward at a maximum surface velocity of about 2 knots, and is bounded by the westerly-flowing North and South Equatorial Currents. During most of the year, the Equatorial Countercurrent flows between 5° and 9° N. latitude. Plant nutrients, the basic source of the food supply for the predacious pelagic fishes such as tunas, are brought to the

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NOTE: The writer also wishes to gratefully acknowledge the cooperation and assistance extended by the crew of the MANNING during the survey.

All charts and illustrations were prepared by Miss Alice Hunt, Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service, Honolulu, T. H.

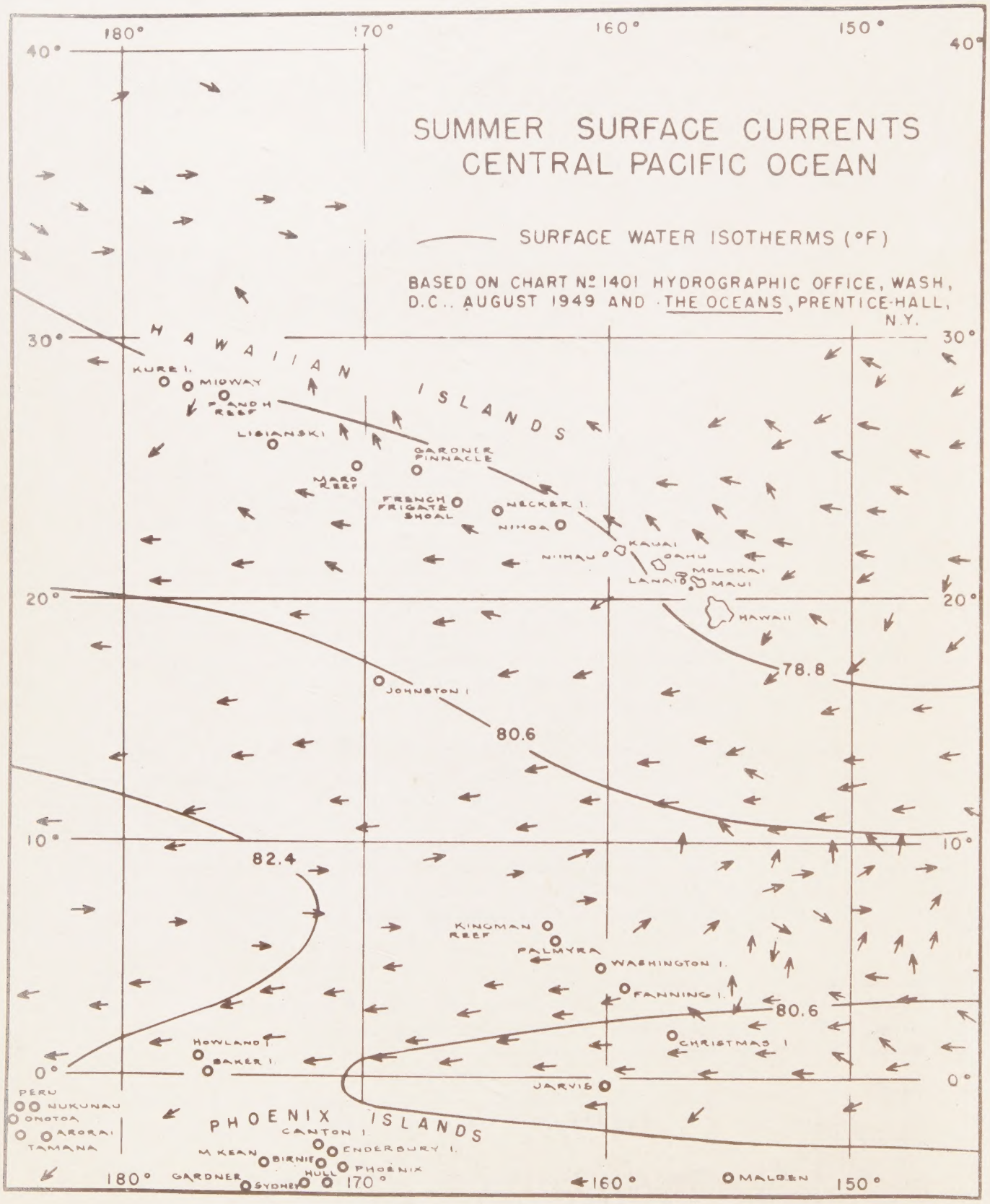

SUMMER SURFACE CURRENTS
CENTRAL PACIFIC OCEAN
SURFACE WATER ISOTHERMS (°F)
BASED ON CHART Nº 1401 HYDROGRAPHIC OFFICE, WASH, D.C., AUGUST 1949 AND THE OCEANS, PRENTICE-HALL, N.Y.
180°
170°
160°
150°
40°
30°
20°
10°
0°
HAWAIIAN ISLANDS
KURE I.
MIDWAY
PEARL & HERMES REEF
LISIANSKI
GARDNER PINNACLE
MARO REEF
FRENCH FRIGATE SHOAL
NECKER I.
NIHOA
KAUAI
NIIHAU
OAHU
MOLOKAI
LANAI
MAUI
HAWAII
78.8
JOHNSTON I.
80.6
82.4
KINGMAN REEF
PALMYRA
WASHINGTON I.
FANNING I.
80.6
HOWLAND I.
BAKER I.
CHRISTMAS I.
JARVIS
PERU
NUKUNAU
ONOTOA
ARORAI
TAMANA
PHOENIX ISLANDS
CANTON I.
ENDERBURY I.
M KEAN
BIRNIE
PHOENIX
HULL
GARDNER
SYDNEY
MALDEN

Figure 1

surface along the northern boundary of the Equatorial Countercurrent by a process of upwelling, due to the earth's rotation causing a divergence of currents on the northern boundary. Because of the upwelling in the region of the divergence, the thermocline is also nearer the surface than elsewhere, a condition that should be conducive to the occurrence of tunas in the surface layers. The Japanese explored and exploited the Equatorial Countercurrent region of the Western Pacific for a number of years prior to World War II, and found the waters between 0 and 7° N. latitudes to be the best fishing grounds for yellowfin tuna. Their explorations extended westward from 170° E. longitude.

A second reason for selecting the Line Islands for study is their proximity to the Hawaiian Islands and hence ready markets and processing facilities for tuna. Third, previous reports from several vessels and from island residents with opportunities to observe tunas in the Line Islands indicated that the abundance of tunas in this area warranted further investigation. Of particular note, the CALISTAR, in February 1949, took 50 tons of yellowfin close to the beach at Fanning Island and another 15 tons at Palmyra, using live bait transported from Mexico. The CALISTAR also reported numerous schools seen in the open ocean of this region. Last, the Line Islands were expected to be more suitable as to weather conditions for operation of the purse seine than the more northerly areas adjacent to the Hawaiian Islands.

From the preceding information, good surface trolling was not unexpected in the Line Islands although the MANNING was unprepared both in quantity and strength of trolling gear for the size of fish encountered and for the number of hours devoted to trolling. (See Description of Gear and Rigging). Also, a great many unavoidable disadvantages were encountered in trolling from the MANNING. The MANNING, basically a purse seiner, is not a troller. The vessel is not as easily maneuverable in and around a concentration of tuna as a smaller trolling vessel would be. Its square stern leaves a large and unfavorable wake for trolling. The seine greatly hampers fishing the stern lines, at least three men being necessary to pass the lines around this obstacle as no fish can be gaffed from the stern itself. On the main deck, gear used in connection with seining is a constant obstacle in landing fish from the sides. Also, the trolling outriggers, of necessity, are mounted too far forward and lines have to be just that much longer to extend beyond the stern sufficiently. In this regard, the practical fishing length of trolling line is limited by drag of the line in the water. The deep draft of the MANNING (13') does not permit exploration of the areas closer in towards the beaches and reefs, the fish signs in these areas being indicative of potentially greater catches.

The MANNING trolled at 7.5 to 8.0 knots, a slower speed producing excessive vibration as the main engine has a considerable range of critical speeds. It was noticed that a reduced trolling speed, (5-6 knots) if possible, might have been more desirable. Slowing the MANNING for a hooked fish often resulted in several strikes on other lines. Possibly the combination of reduced speed, vibration and wake had a favorable effect on the tuna which may not have struck otherwise. It is

believed by the observers that a slower trolling speed would correspondingly reduce the number of losses due to strain on fish and gear and facilitate handling of the smaller fish without necessity of slowing the boat down further.

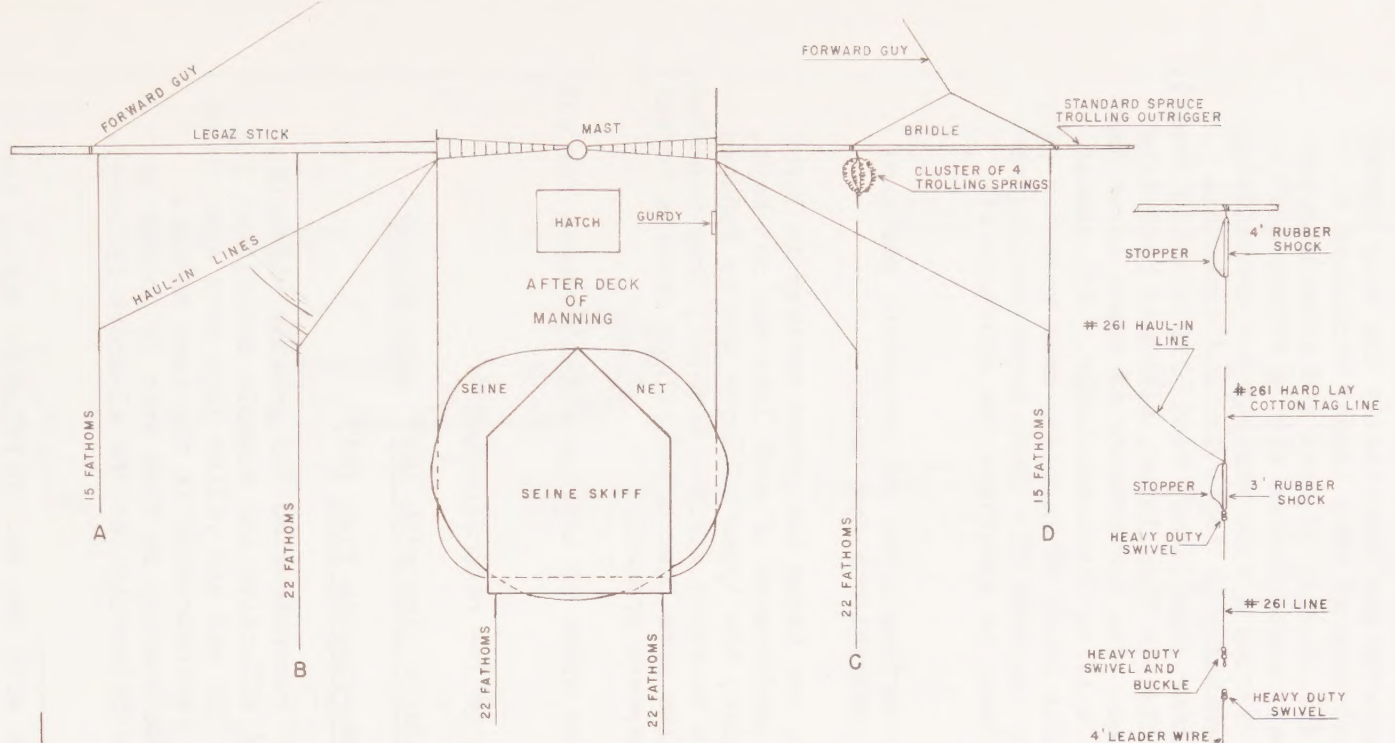
It is also the consensus of observers aboard the MANNING that a standard trolling boat, familiar with the area and properly rigged, would have been able to double, at the very least, the catch of the MANNING. The MANNING was able to troll an average of only 6 lines, whereas a standard troller could have handled 8 to 11 lines. Furthermore, unfamiliarity with the area caused excessive caution in navigation of the MANNING and a loss of early morning and late evening trolling hours. This caution could be reduced and more fishing time used by a smaller and standard trolling vessel.

DESCRIPTION OF GEAR AND RIGGING

Except as noted in Table I, the MANNING trolled six lines, two from each outrigger pole and two astern. Outside lines were 15 fathoms in length and inside and stern lines each 22 fathoms as shown in Figure 2. All lines were approximately 1-1/2 fathoms apart. A 35-foot spruce standard trolling pole (4-1/2" butt) was employed on the starboard side and a 35-foot "Legaz" stick, commonly used in purse seine operation, served as a makeshift trolling outrigger on the port side. When only five lines were fished, the "Legaz" was not used, the fifth line being secured to the base of the port ratlines. Late in the cruise, a seventh line was added to the port trolling pole inside the two already fishing and was approximately 27 fathoms in length. Outside lines were weighted above the leaders with 12 to 16 ounces of seine lead to enable these lines to pass under the others freely during hauling and releasing. Inside lines on the outriggers fished at the edge of the wake and were the most productive. Stern lines fishing in the wake, but 5 fathoms farther aft than inside lines, were next in productivity. The outside lines appeared to receive slightly fewer strikes than the stern lines.

All trolling line was #261, hard-lay, treated, cotton seine twine, except for a two-day trial given the inside starboard line using wire gear with a power gurdy. This wire trolling will be discussed in a subsequent paragraph.

Shocks were of 1/2" diameter rubber tubing in 3 to 4 foot lengths doubled, and of such strength that a force of 75 to 100 pounds was necessary to stretch them to the stoppers, the stoppers allowing a pull from two to three feet. A cluster of four galvanized trolling springs (1-1/2" x 12", No. 10 ga. wire) was used on the inside starboard line, however, and a single spring of the same type on each of the stern lines, the latter with stoppers which prevented more than an 18" elongation of the spring. These single spring shocks required less than 50 percent as much tension to extend them as did the rubber shocks. On each of the side lines, an additional rubber shock cord was rigged ahead of the tag lines as shown in Figure 2.



SURFACE TROLLING GEAR AND RIGGING
CRUISE II JOHN R. MANNING

Figure 2

Interior--Duplicating Section, Washington, D. C. 64283

A No. 10 heavy duty brass swivel was spliced on the trolling line just behind the tag shocks. Where a trolling line joined a leader, a No. 10 heavy duty brass swivel with buckle was spliced. Leaders were from 3 to 5 feet in length and of No. 23 and 24 gauge stainless steel straight wire, 1/16" 7 x 7 stainless steel cable, and 5/64" 1 x 7 stainless steel wire. The No. 24 gauge wire was essentially the only leader used in quantity, however. The end loop of each leader contained a No. 10 heavy duty brass swivel. All forming of eyes and attaching of lures on the cable-type leaders was accomplished with a "Nicopress" tool and sleeve. As the MANNING carried a wide variety but numerically limited supply of lures, it was necessary to improvise and combine a variety of jig parts. Common feather jigs (lead, wood, and plastic heads), large and medium "Fishong" green plastic fish lures, standard bone-type jigs, plugs, and spoons were fished. The performance of these lures and various combinations of jig parts will be discussed later. 8/0 double Mustad trolling hooks and 7/0 double hooks of Japanese make were the only standard trolling hooks carried by the MANNING. Much experimenting resulted in combinations of single hooks to alleviate the shortage of standard doubles.

As to the performance of the various items and component parts of the trolling gear, the following observations are noted:

1. Lures. For many reasons, one being the great variety in lures tested, a detailed record of the performance of each lure was not kept. With knowledge gained on this cruise, the types of lures can be reduced to numbers more practical for such detailed study. However, from repeated observations certain general results have been noted, these results representing a consensus among the observers aboard.

The lures can be listed in the order of average effectiveness for all areas as follows:

a. White bone-type jig (6")— reconstructed [1/]

b. Lead, wooden, or plastic jigs with lai[2/] skin skirts

c. Large "Fishong" green plastic fish (6")

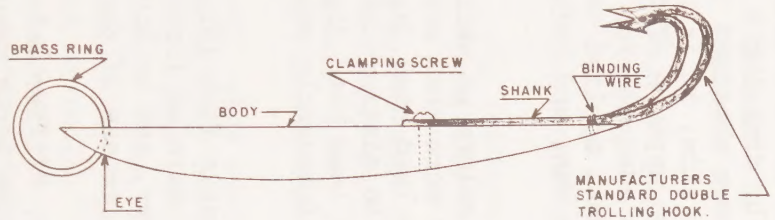
The white bone-type jig, when reconstructed for greater strength, as shown in Figure 3, was the most effective and durable individual jig fished during the entire cruise. The red and yellow jigs were also found to be extremely satisfactory when reconstructed in the same manner. Original manufacturer's hooks broke readily on fish over 35 pounds in weight. (These jigs were designed primarily for the albacore fishery).

1/ Replacing manufacturer's hooks with two No. 10 Pfleuger Martu, the shanks of the hooks bound together to fish like standard double trolling hooks—also reinforcing other jig parts as shown in Figure 3.

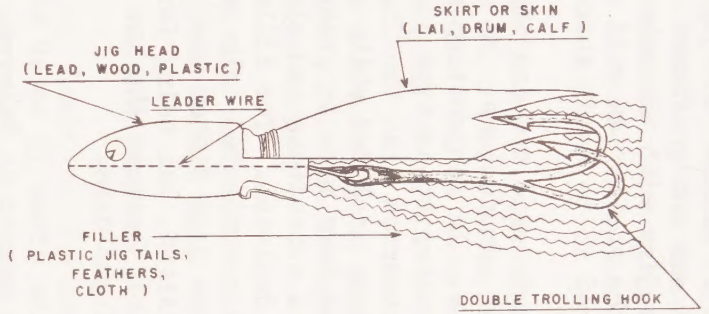
2/ Lai (Scomberoides sp.), fish common to some Central Pacific areas and reaching length of about 18".

EFFECTIVE LURES USED ON CRUISE II JOHN R. MANNING

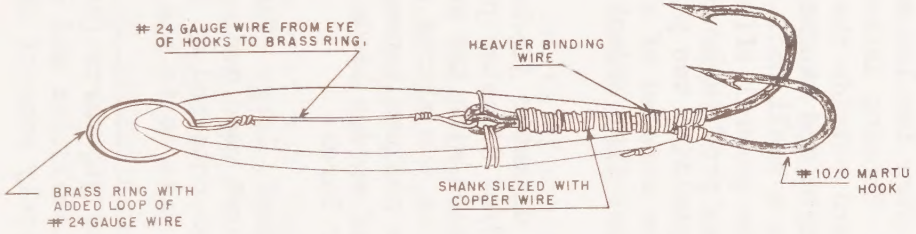
STANDARD BONE TYPE JIG



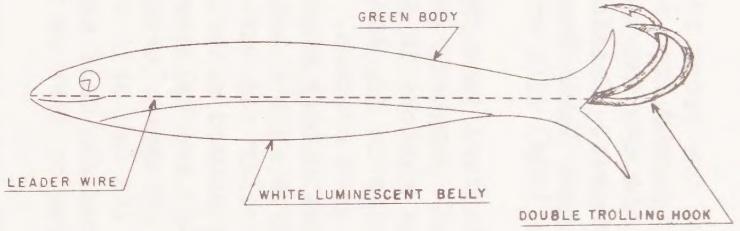
TUNA JIG PARTS


SKIRT OR SKIN (LAI, DRUM, CALF)
JIG HEAD (LEAD, WOOD, PLASTIC)
LEADER WIRE
FILLER (PLASTIC JIG TAILS, FEATHERS, CLOTH)
DOUBLE TROLLING HOOK

RECONSTRUCTED BONE JIG AS USED BY MANNING


24 GAUGE WIRE FROM EYE OF HOOKS TO BRASS RING.
HEAVIER BINDING WIRE
BRASS RING WITH ADDED LOOP OF # 24 GAUGE WIRE
SHANK SIEZED WITH COPPER WIRE
#10/0 MARTU HOOK

LARGE FISHONG PLASTIC LURE



Interior--Duplicating Section, Washington, D. C 64-283

Figure 3

Furthermore, the brass ring, by which the leader is attached to the head of the jig, parted from the strain at times. The jig itself occasionally severed at the eye but this defect was insignificant in comparison to other weaknesses. Reinforced bone jigs with the makeshift addition of No. 10 Pfleuger Martu hooks held the smaller as well as larger yellowfin tuna (12 to 150#) with what appeared to be equal success.

The standard tuna jig lead heads were two and three ounce of several types of both Japanese and American manufacture. No difference in performance was noticed in these types. In conjunction with lead heads, feathers, plastic jig tails, and rubber squid-type jig tails were all tried with good success. It was observed that the lighter colored materials were very definitely superior. These included white feathers, red feathers, red squid-type rubber tails and the same type in green, clear plastic jig tails, a similar red variety, and a substitute red cloth filler which was used when standard materials were depleted. The filler materials (i.e. jig tails 1/) are believed to have contributed only partly, however, to the efficiency of these lures, and these jigs fished most effectively chiefly because of the lai skin skirts utilized, lai being far superior to the standard drum and calf skin, probably because the lai skin is bright, shiny, and effective on dark as well as light days.

Lai skin must be replaced quite often (5 to 10 strikes), and is difficult to obtain. Very few lai were caught at Palmyra, none at Washington or Kingman Reef. Fanning Island, in contrast, contained large numbers of lai both inside and outside the lagoon. These fish were attracted by the deck lights at night and caught on the surface by dragging a piece of white material on a small hook. Some 300 lai were obtained in this manner. As a result of the general effectiveness of lai skin, it is recommended that a troller may profitably devote time to the capture of these small fish. One lai, yielding two pieces of skin, is adequate for each jig. The skin should be scraped of all flesh, wet down, applied to the surface of a plank or other flat object, exposed to the sun, and left to dry before using.

Wooden 3/4" diameter jig heads of various colors as well as red, white, and milky-white 3/4" diameter plastic jig heads were most effective at times when assembled with the same parts as the lead head jigs, lai skins again being used as the skirts on these jigs. No distinguishing fishing effectiveness was noticed between these and the lead head jigs, but the skipping action of wooden heads attracted fish frequently when no strikes occurred on other lures.

At Kingman Reef, large "Fishong" green plastic fish (Figure 3) proved to be the best lures used during the first four days of fishing. Lai skins had not been obtained at that time, however, and no direct comparison could be made as to the relative effectiveness of these two types

1/ Terminology of jig parts ("tails", "skirts", "filler material", etc.) varies with localities and usage. Descriptive terms used throughout report are merely some of the more common expressions.

of lures. (Thus, future surveys may alter the preliminary opinions of these lures). Large "Fishong" lures are easily rigged, hook the tuna well, and are quite durable. Heavy strikes soon carried away the available supply of these lures and smaller (5") green plastic fish were used, but with diminished success.

Wooden plugs and brass spoons commonly trolled in the salmon fishery of Pacific Coast were found to be ineffective in taking tuna on the surface. However, a few strikes were obtained on plugs that had been whittled down at the head to reduce action in the water.

On the basis of the experience gained, it is suggested that a commercial troller in the Line Islands carry an adequate supply of the jigs and parts as summarized below:

a. White, red, and yellow bone-type jigs reconstructed with strongest double troll hooks available as in Figure 3.

b. Large "Fishong" green plastic fish.

c. Wood jig heads, 3/4" diameter.

d. Lead jig heads, standard, assorted sizes not less than two ounce.

e. Plastic jig heads, red, white, and milky white, 3/4" diameter.

f. Plastic jig tails, 3/4" diameter, red, clear, and light green.

g. Red rubber and red cloth as extra filler materials.

h. Jig feathers, 5" or more in length if available, in white, blue, and red colors.

It is believed that larger lures might have been more effective for the larger fish, and that, for instance, lead head jigs up to 10 ounces should be fished. Also, a larger "Fishong" type lure (7") might experience more success than the smaller size now manufactured.

In general, when surface trolling was good, all jigs appeared to fish well, durability becoming the dominating factor in evaluating the lure. Changing lures results in loss of fishing time and employment of men in repairing. Thus, a new type jig is suggested on the lines of the "Fishong" plastic lure, pierced longitudinally for insertion of leader and attachment of hooks. This lure could be either made of hard glass, (a bright or luminescent material imbedded) or constructed of aluminum. It should be approximately 7" in length.

2. Shocks. In general, the shocks were not of sufficient strength or length, the fish often working against the stopper at which point the shock ceases to function and results in excessive strain on either the gear or the tuna's jaw causing many losses of gear and fish. This fault was quickly recognized but the supply of shock cord on the MANNING was limited.

A cluster of four galvanized trolling springs (1-1/2" x 12" -- No. 10 ga.) was satisfactory as to strength and no stopper was necessary. However, the springs would not stretch enough for the "play" desired in holding the larger fish and thus many potential catches were lost. Single trolling springs of the same type on the stern lines conversely proved excessively weak, most fish over 10# hitting the stopper with a jerk that resulted in a notably larger percentage of losses than on lines with stronger shocks.

Until further experimentation can be carried out, it is recommended that 1/2" black rubber tubing or equal be used in at least triple lengths of from six to ten feet, such that the pull required to stretch the shock to the stopper be in the neighborhood of 200 pounds. Such a shock would tend to constantly "play" the fish and avoid the abrupt and severe jolts that caused many losses..

3. Line. No. 261 thread, cotton, hard-lay seine twine was ideal both as to strength and size for gripping and no trolling hand line of lesser qualities would be recommended. The line had been treated with a green solution of copper napthenate and later stretched with block and tackle to prevent kinking.

4. Swivels. No. 10 brass heavy duty swivels were highly satisfactory as were these same swivels with buckles. No swivel, snap, or connector of lesser strength should be used. No. 6 brass swivel eye snaps separated with big strikes. No other standard type of swivel was tested.

5. Wire trolling gear. The use of wire gear with proper trolling gurdies may be the only means of eliminating the manpower necessary in hauling big fish by hand. Many times, 4 and 5 men were necessary to haul and handle the tuna over 100 pounds in weight from the MANNING, so wire gear, originally planned for deep trolling, was given a two-day trial on surface trolling as well. Initially, the wire (5/64" 1 x 7 stainless steel) led through a lizard, and was held in fishing position on the starboard trolling stick by a stopper on the wire which would not pass this lizard. A strike, however, slammed the wire against the framework above the gurdy and caused losses of strikes estimated at between 70 and 80 percent. Furthermore, this particular gurdy hauled at an exceedingly slow rate (40 rpm) and could not be regulated to apply the desired tension on the fish. Its use was thus discontinued for the remainder of the cruise.

Wire trolling gear has the advantages that it is relatively invisible in the water and can be let out farther as mechanical power is used for

hauling. As a result, the wire gear received a noticeably and substantially greater number of strikes than the handline gear. By rigging trolling wire through a sheave on the trolling outrigger, with the sheave suspended from an adequate shock, "play" could be maintained on the fish during hauling. A lizard and separate hauling arrangement could be used in retrieving the main wire.

6. Trolling Poles. The "Legaz" stick was, of course, strong and rigid, without the flexibility desired in trolling outriggers. This stick was used merely as a matter of convenience. The starboard outrigger gave an additional 3' to 4' of "play" at the tip but often reached a strain which, if exceeded, might have broken it. The forestay was free to move on a bridle that in turn was lashed at the tip and midpoint of the pole. A more rigid arrangement would, therefore, be needed for complete protection of the pole on larger strikes. No outrigger of less strength than that used by the MANNING should be considered.

7. Leaders. Stiff wire or cable eventually kinks, these kinks being difficult to remove and invariably causing the leader to part. This was true of both No. 23 and 24 gauge straight wire and 5/64" 1 x 7 cable. Furthermore, kinks hampered the fishing efficiency of the lure, affecting its action in the water. The 1/16" 7 x 7 cable, in contrast, proved to be of greater value due to its flexibility and is highly recommended. Furthermore, it is easily rigged with a "Nicopress" tool and sleeve. The MANNING had little of this cable aboard, unfortunately, and relied mostly on No. 24 gauge leader wire which, however, with proper care, was utilized satisfactorily.

All leaders were, of necessity, made up in three to five foot lengths because in gaffing the fish, both for sufficient grip and prevention of cuts, the line must be held above the leader with one hand while the other arm is free to gaff. With longer gaffs and a more advantageous deck arrangement, much longer leaders could be used. One leader of eight feet in length was tried with noticeably increased numbers of strikes. A local Hawaiian fisherman aboard confirmed the opinion that leaders should be 8 to 12 feet in length and that beyond this length the increased numbers of strikes that might be obtained would not offset the difficulties in handling the gear.

8. Hooks. The MANNING was equipped with types of trolling hooks which later proved unsatisfactory, these deficiencies accounting for the majority of losses. Much improvising and experimentation with hooks was undertaken in an effort to overcome the weaknesses and shortages. Single hooks, both Pfleuger Martu and Sobey types (9/0 and 10/0) were tried but these failed to hold as well as doubles. Adding two of these hooks to a lure, back to back, resulted in the same lack of success.

For lack of choice, main reliance was placed on Japanese double troll hooks. These were undersized, however, and frequently pulled

loose from the fish. Japanese hooks did, nevertheless, show remarkable strength, being of heavy stock and high carbon content. A smaller number of 9/0 double Mustad trolling hooks were also relied upon, these being more satisfactory as to size. But the lower carbon content and smaller stock material resulted in frequent bending and an even greater loss of strikes than with the Japanese hooks. Thus, no hook or combination of hooks carried by the MANNING on this cruise was dependable or satisfactory from all standpoints. It is recommended that trolling hooks in the Line Islands be of the strongest stock available and standard doubles of a size not exceeding a Pfleuger Martu No. 10/0 hook.

Rough weather necessitated positioning the outriggers at an abnormally high angle with the water to prevent their submerging on a roll. The outside lines, in particular, were adversely affected by this angle, the outside jigs not fishing properly, resulting in a higher percentage of losses (probably 60-70 percent). A strike would tend to raise the fish upward and dislodge the hook. The losses were somewhat offset by using triple[1/] 10/0 Martu hooks which were attached to a wood head jig. These hooks held the strikes but some time was lost in extracting them from the fish after gaffing. A wood head jig was used with these triple hooks as, being a bulky type of jig, it tended to cover the hooks.

9. Gaffs. A number of halibut-type gaffs were lost on big fish and particularly on sharks until a separate shark gaff with manila line was used. The fishermen varied in their individual preferences for gaffs but a strong wooden handle about 4' long appeared the most generally acceptable. Common axe handles are ideal for these. Also 6' gaffs of heavier stock than can be purchased in Honolulu are also desirable as well as a wide assortment of halibut-type gaffs, 6" to 24" in length.

10. Break-aways.[2/] The use of break-aways on big fish is not recommended for a commercial trolling operation due to the obvious delays in recovering line as well as the tangles that would occur if more than one fish struck simultaneously.

TROLLING OPERATIONS AND RESULTS

In general, trolling was conducted within six miles of the islands or reefs, as lee areas were deemed necessary in working purse seine gear, no scouting being done further out except on courses between islands which were mostly travelled at night. At least one circle was made of each new atoll, the strikes and fish signs noted. A marked similarity

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1/ Makeshift arrangement by seizing three hooks with wire to hold in place approximately 120° apart.

2/ Allowing fish to run out large amount of trolling line and "playing" fish by hand during hauling.

was observed in the occurrence of yellowfin for different areas trolled. In all cases, the concentration of yellowfin was found to be on the westerly side of the areas, this side corresponding to a lee as prevailing winds were from NE to E. In trolling these waters, the majority of strikes per unit of effort were obtained within two miles of the beach, on and around the reefs and shoal areas. A number of "tide rips" 1/ were crossed both in open ocean and adjacent to land areas. However, no time was devoted to scouting these regions and for future trolling in the Line Islands, it is recommended that the trolling areas be expanded not only to include the "tide rips", but to include areas where currents are known or believed to converge or diverge, particularly in shoaling waters as indicated by the navigational charts. The foregoing are common means by which West Coast fishermen locate potential tuna schools and should be explored when more time permits.

The MANNING trolled a total of 285-1/2 hours, catching 882 yellowfin (Neothunnus macropterus) weighing 29,319 pounds. Thus, the average weight for all yellowfin was 33.9 pounds. A total of 178 wahoo or ono (Acanthocybium solandri) were taken, these fish estimated to weigh 5,888 pounds. In addition, a small number of skipjack (Katsuwonus pelamis) and miscellaneous fish were trolled, including rainbow runners (Elagatis bipinnulatus) and barracuda (Sphyraenidae). The yellowfin were, in general, mixed fish ranging from 8 to 165 pounds although the surface trolling was highly selective as to smaller sizes due to gear weaknesses already discussed. Many strikes indicated yellowfin of well over 200 pounds.

In Table I, the catch is broken down by day and area, each tuna having been weighed individually, while the wahoo weights were estimated. From these catch data, the insignificant number of skipjack caught is apparent. The catch of yellowfin per line per hour indicates Kingman Reef as the most productive area with 26.4 lbs. Washington Island, Christmas, Palmyra, and Fanning were next in the order named.

In Table II is shown the surface trolling catch of yellowfin per day for three areas for each two-hour period of the day to indicate the possible variations in availability of tuna throughout the day. It appears that the tuna in these areas were trolled with near-equal success throughout the entire day.

Actually, some 17 scattered atolls and reef areas comprise the Line Island chain, which lie near 160° W. longitude and between about 6° N. latitude and just below the equator as shown in Figure 1. As already indicated, the MANNING specifically surveyed five of these areas on Cruise II, passing others on travelling courses.

The atolls throughout the Line Islands are basically coral bounded by a fringing reef and enclosing an inner lagoon. Adjacent waters drop off quickly to depths of 1000 fathoms and more, these depths extending between fishing areas. More detailed descriptions of areas surveyed as well as results attained are as follows:

1/ Local current interfaces

TABLE I - CATCH DATA

Date	Area	No. lines Out	Trolling Hours (2)	No. Tuna (3)	Lbs. Tuna	No. Wahoo (4)	Lbs. Wahoo (5)	No. Tuna/ line/hour	Lbs. Tuna/ line/hour	No. Skipjack (6)
Apr. 22	Kingman Reef	5	9 1/2*	20	767	1	35	.42	16.2	3
23	"	5	10	79	2665	2	70	1.58	53.3	5
24	"	5	8	53	1955	7	245	1.32	48.8	2
25	"	5	9	59	1666	5	175	1.31	37.0	0
26	"	6	1 1/2	5	136	0	0	.56	15.1	0
May 28	"	6	2	15	475	6	175	1.25	39.6	0
29	"	6	10	32	954	7	230	.53	15.9	0
30	"	6	10	49	1592	8	225	.82	26.6	0
31	"	6	4 1/2	27	885	17	465	1.0	32.8	0
		7 (1)	5 1/2	25	957			.65	24.9	0
June 1	"	7	7	6	239	8	245	.12	4.9	0
2	"	7	3	3	175	0	0	.14	8.3	0
Totals & Av.		5.9	80	373	12,466	60	1865	.79	26.4	10
Apr. 27	Palmyra	6	10	95	1941	4	140	1.58	32.4	4
28	"	6	7*	17	319	5	165	.40	7.6	0
29	"	6	6*	6	192	0	0	.17	5.3	0
May 1	"	6	4*	0	0	0	0	0	0	0
27	"	6	9 1/2	29	995	7	162	.51	17.5	0
28	"	6	3 1/4	18	385	6	185	.92	19.7	1
June 2	"	7	3	1	15	0	0	.05	.7	0
3	"	7	5 1/2	17	476	4	130	.44	12.3	0
4	"	7	4 1/2	10	290	4	98	.32	9.2	0
Totals & Av.		6.35	52 3/4	193	4613	30	880	.58	13.8	5

CATCH DATA - Cont.

Date	Area	No.lines Out	Trolling Hours (2)	No. Tuna (3)	Lbs. Tuna	No. Wahoo (4)	Lbs. Wahoo (5)	No. Tuna/ line/hour	Lbs. Tuna/ line/hour	No. Skipjack (6)
May 3	Washington	6	11*	42	1680	9	400	.64	25.5	0
4	"	6	10 1/2	42	1504	15	600	.67	23.9	0
5	"	6	10*	16	680	4	140	.27	11.3	1 (7)
24	"	6	7 1/2	41	1314	1	40	.91	29.2	0
June 5	"	7	9 (8)	22	843	17	440	.35	13.3	0
6	"	7	10 1/4	33	1080	16	393	.46	15.0	0
Totals & Av.		6.3 av.	58 1/4	196	7101	62	2013	.53	19.3	1
May 6	Fanning	6	1	3	120	0	0	.50	20.0	0
8	"	6	6*	2	66	0	0	.06	1.8	0
9	"	6	10	1	50	0	0	.02	.8	0
10	"	6	5 1/2	0	0	0	0	0	0	1
11	"	6	2 1/2	0	0	0	0	0	0	0
23	"	6	4	0	0	0	0	0	0	0
June 7	"	6	3 1/2	9	213	0	0	.43	10.1	0
Totals & Av.		6 av.	32 1/2	15	449	0 av.	0	.08 av.	2.3 av.	1

CATCH DATA - Cont.

Date	Area	No. lines Out	Trolling Hours (2)	No. Tuna (3)	Lbs. Tuna	No. Wahoo (4)	Lbs. Wahoo (5)	No. Tuna/ line/hour	Lbs. Tuna/ line/hour	No. Skipjack (6)
May 12	Christmas	6	7 1/2	28	1343	1	35	.62	29.9	0
13	"	6 (9)	7 1/2	23	1100	2	100	.51	24.5	0
15	"	6	11	5	237	5	206	.08	3.6	0
16	"	6	11*	5	239	1	45	.08	3.6	0
17	"	6	10 1/2	13	537	5	279	.21	8.5	0
18	"	6	5	9	405	3	105	.30	13.5	0
19	"	6	5	15	569	6	235	.50	19.0	0
20	"	6	4 1/2	7	260	3	125	.26	9.6	0
Totals & Av.		6	62	105	4690	26	1130	.28	12.6	0

(1) 7th line added on May 31 just before noon.
(2) Includes hours trolled in circling islands on days starred (*).
(3) Yellowfin tuna (Neothunnus macropterus)
(4) Ono (Acanthocybium solandri)
(5) Estimated weights
(6) Katsuwonus pelamis
(7) Little tunny or Kawakawa (Euthynnus yaito)
(8) Commenced fishing after 0900
(9) Seine set in morning - no trolling for 3 1/2 hours

Table II - Number of Yellowfin Caught by Two-Hour Periods Per Day

Time	Kingman Reef-6 days(1)		Palmyra-3 days(1)		Washington-4 days (1)	
	No. Yellowfin Caught	Catch/two-Hour period Per Day	No. Yellowfin Caught	Catch/two-Hour period Per Day	No. Yellowfin Caught	Catch/two-Hour period Per Day
0700-0900(2)	74	12.3	10	3.3	6	1.5
0900-1100	82	13.7	13	4.3	26	6.5
1100-1300	72	12.0	38	12.7	49	12.3
1300-1500(2)	39	6.5	32	10.7	38	9.5
1500-1700(2)	59	9.8	39	13.0	35	8.8

(1) Only data are used for full trolling days (between 0700 and 1700). Insufficient data are available for Fanning and Christmas Islands.

(2) Figures low during these hours only because fishing grounds were not reached without some scouting and were left earlier than 1700 on run to anchorage, trolling lines still out.

1. Kingman Reef. As seen in Figure 4, Kingman Reef is a triangular atoll, almost submerged, with a horseshoe of constant breakers to the east and a shoal area of not less than 4 fathoms to the north, west, and south. Only small patches of coral on this eastern horseshoe are visible at low tide. As Northeast trade winds predominate, the inner waters of Kingman Reef, from 6 to 45 fathoms in depth, afford a good protected anchorage for small boats. On April 22, the first day at Kingman Reef, the MANNING circled the area along the course line shown on Figure 4, this circle requiring 3 hours. No birds or fish signs were seen, and no fish were caught along this track in any locality except that in the shaded area shown. A small scattered school of large porpoise was passed off the NE side, however. Upon entering the shaded area of Figure 4, the MANNING began catching fish with results as shown in Table I. Practically all catches were made within 1/2 mile of the shoal or green water, and best trolling was found within 1/4 mile. Surface trolling (77 of the 80 hours) was confined to the area indicated, not only because of the good catches but because of the large schools of tuna sighted in this locality. A detailed account of these schools is as follows:

Date	Species	Est. Size of tuna	Est. Size of school	
4/22	Yellowfin	25-45#	at least 50 tons	Breezing,[1] travelling slowly east to west in manner similar to Central American schools.
4/23	Yellowfin and skipjack	---	50-60 tons	Breezing, travelling fast, mixed school
	Yellowfin	---	large	Travelled 1/4 mile ahead of boat at all times.
4/25	Skipjack	1-2#	large	Shiners,[2] jumpers--appeared in 3 different schools during day.
5/29	Skipjack	3-8#	very large	Breezing, some jumpers, off NW tip in 350-400 fathoms. Similar but smaller school sighted later in day.
5/30	Yellowfin	15-60# mixed	small	Breezing, slow-moving. A second and similar school also seen on same day.

1/ Breezing is a term applied to a school of fish having the appearance of a wind disturbance or "tide rip" (e.g., a rippling effect).

2/ One indication of fish is observing their sides or bellies flashing or "shining" in the water as the fish turns partially over. Shiners can be seen at great depths and distances depending on type of fish and brightness of day.

NOTE: The behavior of tuna in the above table is as expressed by Captain Kursar as well as other west coast fishermen aboard with considerable fishing experience in Mexican and Central American waters. All comparative estimates of school sizes are also based on West Coast tuna standards.

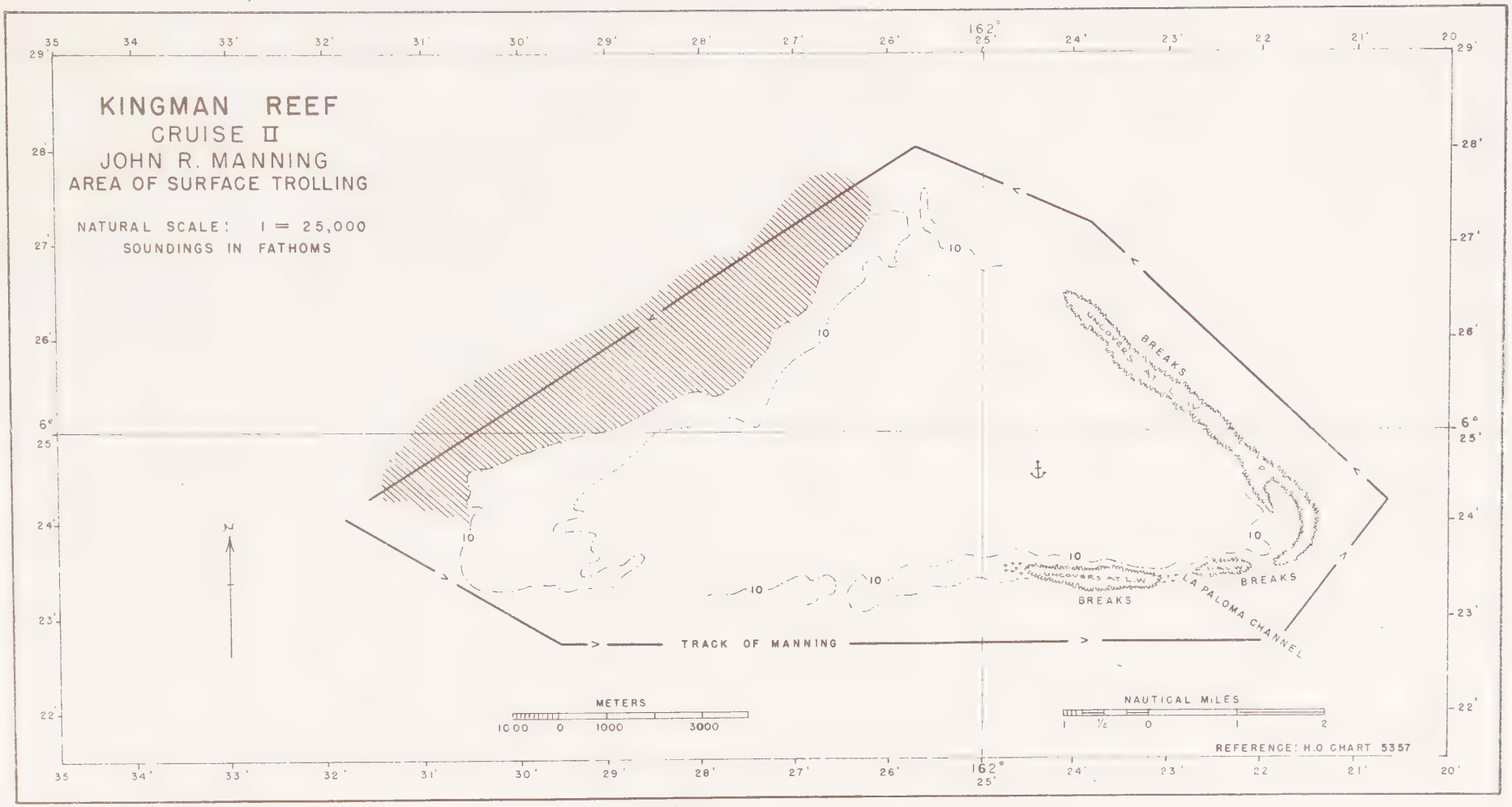

Figure 4

Interior--Duplicating Section, Washington, D C 8-283

The tuna schools encountered were not trolled specifically except during passing and the time required toobserve behavior. The MANNING, rather, continued on a direct run from the NW to SW tips and back. The great majority of tuna was caught among scattered jumpers or at times when there were no visible fish signs. As very few birds were observed at Kingman Reef in comparison to other areas, fish were located mainly by trolling strikes or the observance of jumpers.

The size-frequency of yellowfin caught in each area has been graphed (Fig. 9). All yellowfin taken were either measured (total length), weighed, or both. Where only lengths were taken, the weight data were obtained from a length-weight study of yellowfin in Hawaiian waters. As seen in Figure 9, a distinct mode appears between lengths of 75 and 80 cms., this class weighing about 20 pounds. A second distinct size group is suggested by the rise between 100 and 120 cms., these tuna weighing about 60 pounds. With proper trolling gear, this second and larger class of yellowfin would have undoubtedly been more distinct.

Of considerable nuisance value was the shark population at Kingman Reef, these being 5-6' in length and believed to be of the Gray shark group (genus Eulamia). They would follow the boat in schools of 100 or more, during trolling, frequently striking the lures even at eight knots, the MANNING landing 14 of them. A number of tuna and wahoo(ono) were lost to sharks when unavoidable delays occurred in hauling lines. Those fish (9 yellowfin, 8 wahoo) partially eaten and landed were included in the catch data, the weights estimated as carefully as possible, after which the fish were discarded.

Little protection from prevailing winds is afforded outside the lagoon by the breakers at Kingman Reef and the seas were constantly rough 10 out of 12 days fishing. It may be significant that the two days of comparative calm corresponded to the almost complete absence of tuna catches (Table I June 1, 2). However, insufficient data are available at this time for a correlation of tuna occurrence with either or both state of the weather or the moon phase. Also, several schools of porpoise 1/ were observed at Kingman Reef as well as other areas trolled but they were not seen travelling with tuna nor was any correlation noticed as between the occurrence of porpoises and tuna.

2. Palmyra. This atoll consists of a series of islets with a well-marked channel leading into the west lagoon as shown in Figure 5. The channel is still quite passable, being 30' in depth, although some shoaling has been reported. The MANNING was secured to a dock each evening in the west lagoon and obtained fresh water from nearby rain-water tanks.

1/ Not able to obtain specimen for positive identification. All porpoises observed were black to brown-grey color on the back and light grey to white underneath with no distinct color line. No porpoise known to fishermen as "spinners" and "white bellies" were seen. Porpoise sometimes appeared as line of breakers, nearly 3/4 mile in length, but mostly "played" leisurely off bow in small numbers.

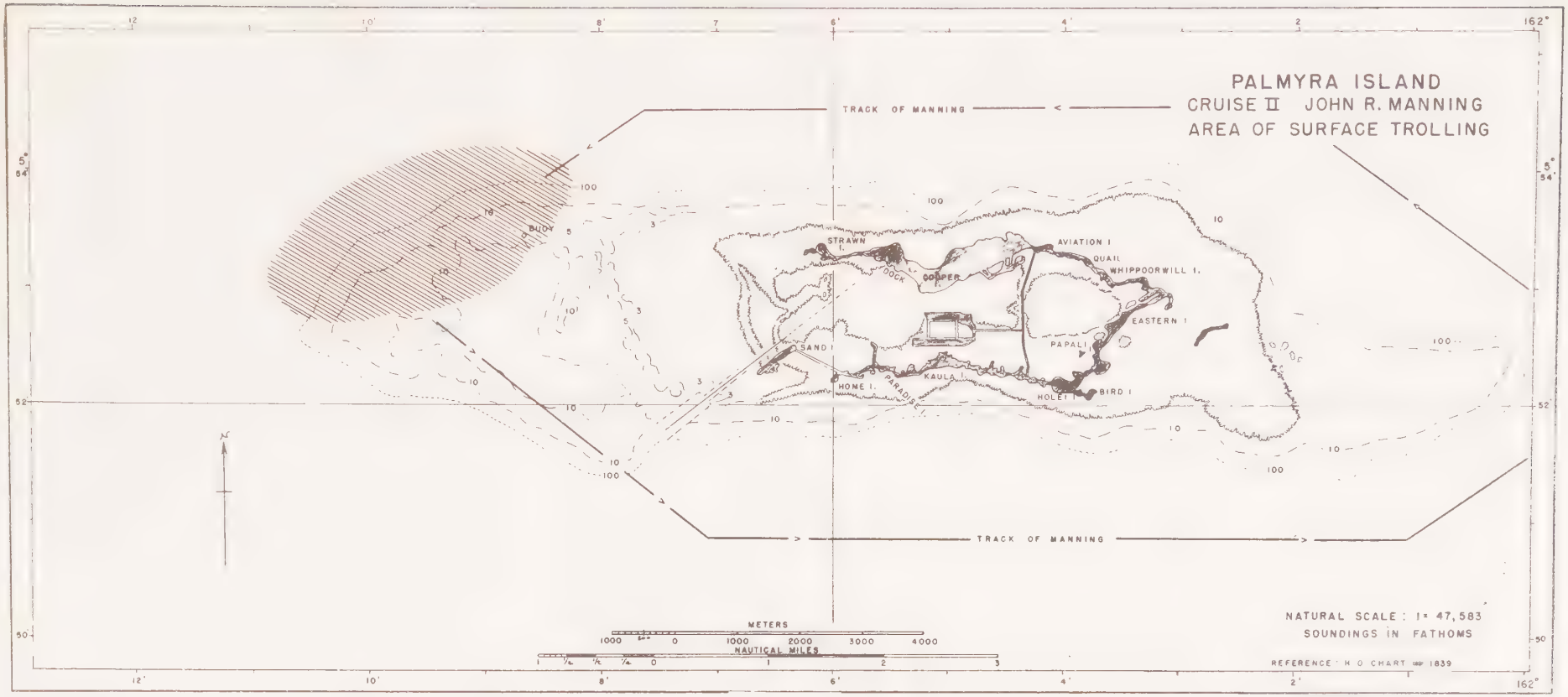

Figure 5

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In contrast to Kingman Reef, Palmyra affords a fair lee on the west side and is better suited to small boat operation.

Three circles of Palmyra were made at a distance of from one to two miles from the beach, (approximately along the track on Figure 5), on April 28, 29 and May 1. Each circle required 2-1/2 hours travelling time. Great flocks of birds, (boobies, terns, and frigates) were seen working both on and around the easterly reef (partially shown in Figure 5) and the westerly reef. Large numbers of porpoise were also observed on the east side but no tuna were caught on the windward sides of Palmyra. Surface trolling on other days (45¾ hours) was confined to the shaded area shown in Figure 5, the similarity in specific locality to that trolled at Kingman Reef immediately becoming apparent. Birds 1/ were numerous from the outer buoy shown in Figure 5 to a distance of some 4 miles to the NW, west, and southwest of this buoy. The birds flew low and scattered when scouting, frequently flocking together to work on temporary concentrations of food organisms. Under these fast-moving flocks, tuna were observed jumping often, appearing momentarily, submerging, and reappearing some distance away. In general, the bird flocks and tuna were difficult to approach, being very fast and wild. On June 3, a small school of skipjack was sighted travelling ahead of the MANNING but these fish failed to take the lures.

From previous reports of persons familiar with Palmyra and surface trolling there, the rather poor result obtained by the MANNING, (Table I), is not a year-around situation, and there is reason to expect that Palmyra is a good trolling area during some seasons. Indeed, the largest catch in numbers of yellowfin in a single day during the entire cruise was made at Palmyra on April 27 after which the trolling fell off considerably.

From Figure 9, the yellowfin at Palmyra are seen to have a pronounced mode between 70 and 75 cm., length which corresponds to individual weights of little more than 15 lbs. A group of larger size is again indicated near 110-115 cms., or just over 60 lbs., individual weight. The yellowfin caught at Palmyra were smaller on the average than at any of the other four areas.

3. Washington Island. At Washington Island the reef extends approximately seven miles in a northwesterly direction as indicated in Figure 6. Washington has no noticeable lee and appears to be at or near the convergence of the easterly flowing Equatorial Countercurrent with the westerly or northwesterly South Equatorial Current. The winds were always strong and variable, this being the usual condition according to residents of the island. The net result is an almost perpetually confused and rough sea. The anchorage is virtually unprotected and not to be recommended for small boats. The currents are exceedingly strong. Small boat landings ashore are usually hazardous and made only with local native help making fresh water difficult to obtain at Washington. Regular and heavy rains may be depended upon according to the local plantation officials.

1/ Again, mostly boobies and brown terns with a few frigate birds and white Fairy terns--the same types of birds and relative proportions were seen in every area in the Line Islands.

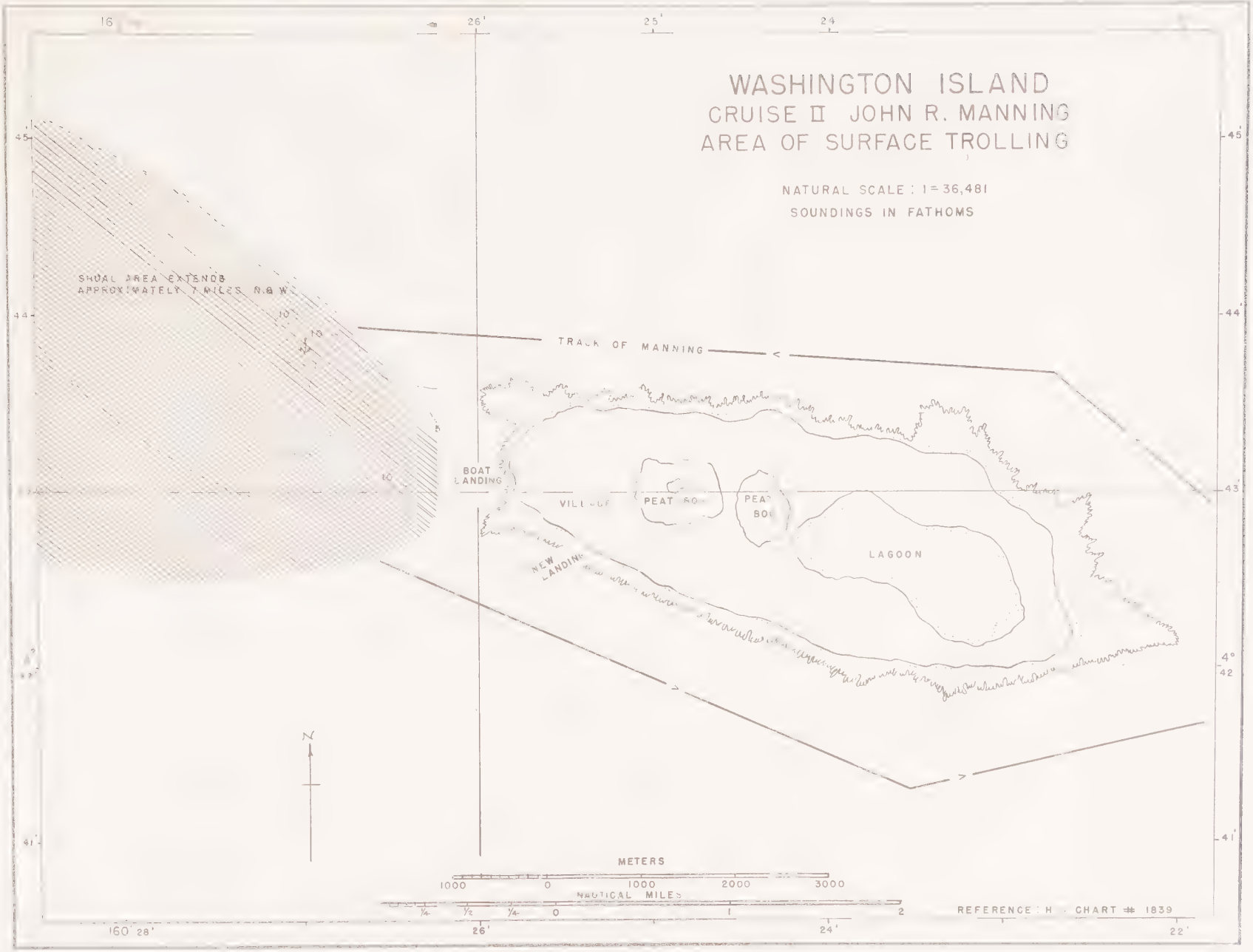

Figure 6

Interior - Duplicating Section, Washington, D. C. 842

On May 3 and 5 circles were made of Washington Island along the track shown on Figure 6, each circle requiring approximately three hours. No fish or birds were seen on the south, east, or north sides during either of these days, and trolling (22¾ hours) was thereafter confined to the shaded area (Figure 6). Surface trolling along this reef yielded catches in numbers and tonnage second only to Kingman Reef (Table I). Tuna behaved similarly to those observed at Palmyra as did the birds which were almost constantly present in large numbers. Three schools of tuna were observed at Washington as follows:

Dates	Species	Est. Size of Tuna	Est. Size of schools	Behavior
May 4	Yellowfin	Mixed	Large	Breezing, boat able to approach, distributed over 3 acres, moving from west to east—2 separate schools.
June 5	Skipjack	20 lbs.	Small	Jumping all around boat momentarily.

Again, the skipjack failed to strike in numbers. Yellowfin were obtained by trolling from one concentration of birds to another or through scattered jumpers.

4. Fanning Island. An excellent lee area exists at Fanning (Figure 7) and according to island residents, this area contains numerous schools of tuna at various times of the year. A few reports, notably from the CALISTAR (Pacific Fisherman, June, 1949), indicate that Fanning Island may have its best fishing during the winter months. The MANNING, unfortunately, encountered very few tuna at Fanning (Table I). On May 8, a four-hour circle was made of Fanning Island with no birds or fish seen. Again, most trolling time (26½ hours) was devoted to the area as shaded in Figure 7. Very small scattered schools of yellowfin were seen and trolled off Whaler's anchorage but few fish were caught and generally the bird and tuna activity was far less than at any other area surveyed on this cruise. The mode of yellowfin caught (Figure 9) represents a catch from one school and cannot be taken as representatives of the area due to insufficient data.

The MANNING was moored to the buoy outside the English Harbor shown in Figure 7 each evening while at Fanning. From this buoy, yellowfin were observed jumping within 100 yards of the beach on one occasion, possibly indicating that the MANNING may have unavoidably passed up a small trolling area close in.

5. Christmas Island. This island is the largest in the Line group, having a land area of 160 square miles with a resulting large and calm lee area to the west and a good anchorage (Figure 8). No fresh water is available at Christmas Island and rainfall, according to the local plantation manager, is light and irregular.

Figure 7

Interior—Duplicating Section, Washington, D. C. 4263

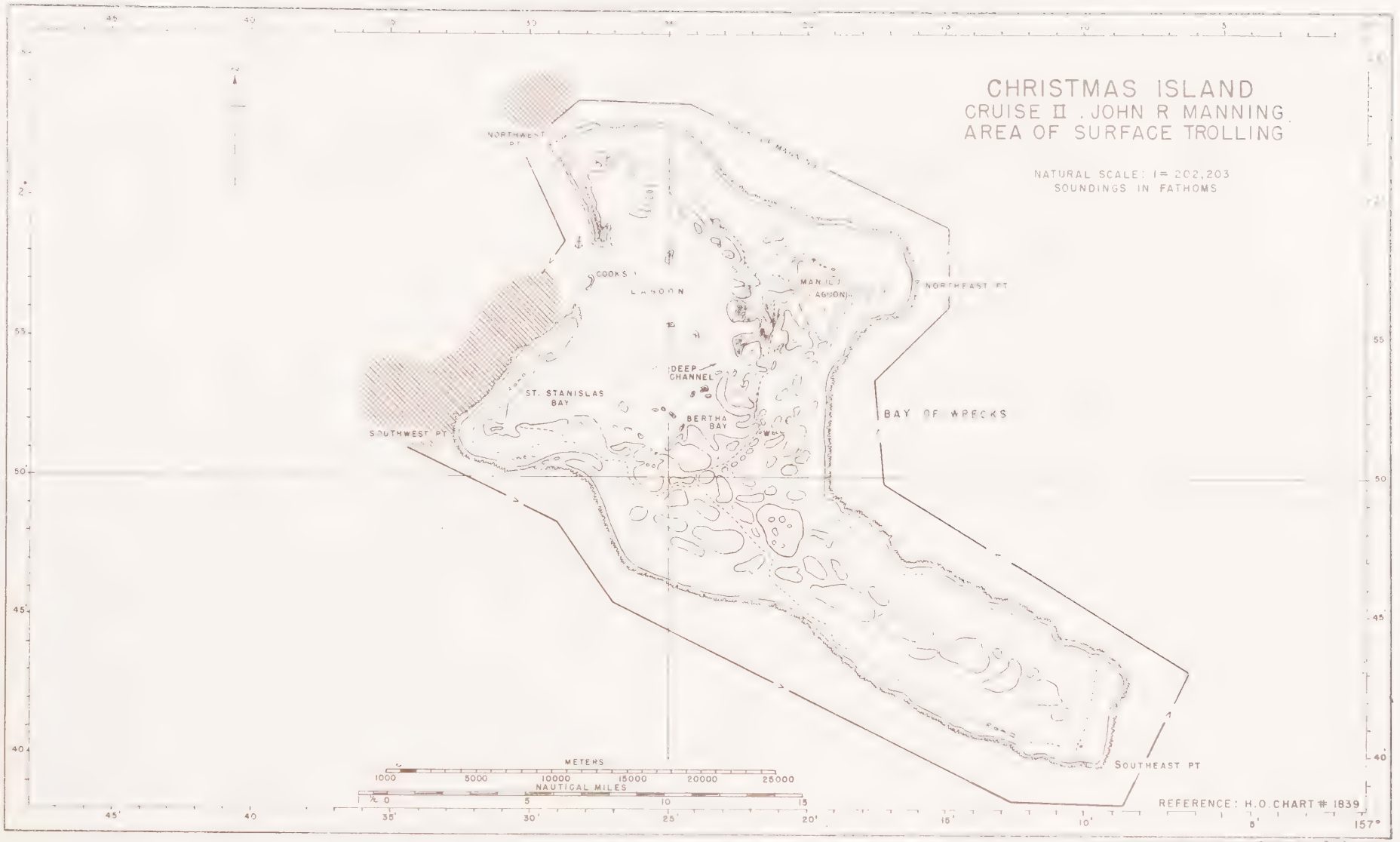
CHRISTMAS ISLAND
CRUISE II . JOHN R MANNING
AREA OF SURFACE TROLLING
NATURAL SCALE: 1= 202,203
SOUNDINGS IN FATHOMS
NORTHWEST PT
COOKS LAGOON
MANILA LAGOON
NORTHEAST PT
DEEP CHANNEL
ST. STANISLAS BAY
BERTHA BAY
BAY OF WRECKS
SOUTHWEST PT
SOUTHEAST PT
METERS
1000 5000 10000 15000 20000 25000
NAUTICAL MILES
0 5 10 15
REFERENCE: H.O. CHART # 1839
157°

Figure 8

A complete circle of Christmas was made on May 16, the track shown on Figure 8, this circle requiring eight hours to complete. No birds or fish were seen until the MANNING arrived at the NW point in which area birds were numerous but trolling spotty. The area around the SW point as shaded in Figure 8 yielded the better catches and 54 hours were devoted to trolling the entire westerly side of Christmas mostly off the SW point. Trolling was good on May 12 and 13 (Table I) during which time the yellowfin were found to be feeding on small, red, crab megalops larvae. These appeared in quantities sufficient to plug the heat exchangers on the MANNING at night. With the disappearance of these crabs the trolling productivity declined greatly as did the indications of fish and bird activity. The tuna were then feeding primarily on squid. On May 13, during the second day of trolling, a large school of yellowfin mixed with skipjack was encountered off the SW point, the fish within the school actually moving fast in separate groups with birds working overhead. The composite groups made up one distinct school which covered a large area and struck the lures consistently.

From Figure 9, the absence of the small size group of yellowfin is noteworthy, the one mode being between 105-110 cms with the largest number of individuals weighing about 50 lbs. These tuna were mostly taken from as close as 200 yards off the beach at the SW point to as far out as 2 miles.

Reliable sources have reported that the NW point of Christmas Island is the more productive and consistent tuna ground, although this was not the case at the time of survey by the MANNING. Also, Captain Northrup Castle of Honolulu, who has fished commercially throughout the Line Islands and who is, incidentally, an amateur ornithologist, reports that the booby bird population of Christmas Island is many times as large as that seen over adjacent waters. Captain Castle states that the main body of birds travels each morning in a northerly direction from Christmas Island to an area some 200 miles distant on a course line to Honolulu, in the region of the convergence of the Equatorial Countercurrent with a northwesterly current originating at Christmas Island (possibly the South Equatorial Current). Captain Castle claims to have visited this area on at least six different occasions and has seen each time these booby birds "by the thousands" working over a "tremendous" concentration of breezing yellowfin. Captain Castle has trolled yellowfin in this area exceeding 300 pounds. He also claims that the birds return each evening to Christmas Island flying high and may be observed from the NW point.

Captain Castle further states that the local current interfaces ("tide rips") in the Line Islands and not the reef areas contain the greater concentrations of tuna. This corresponds to experience of the Japanese elsewhere in the Pacific.

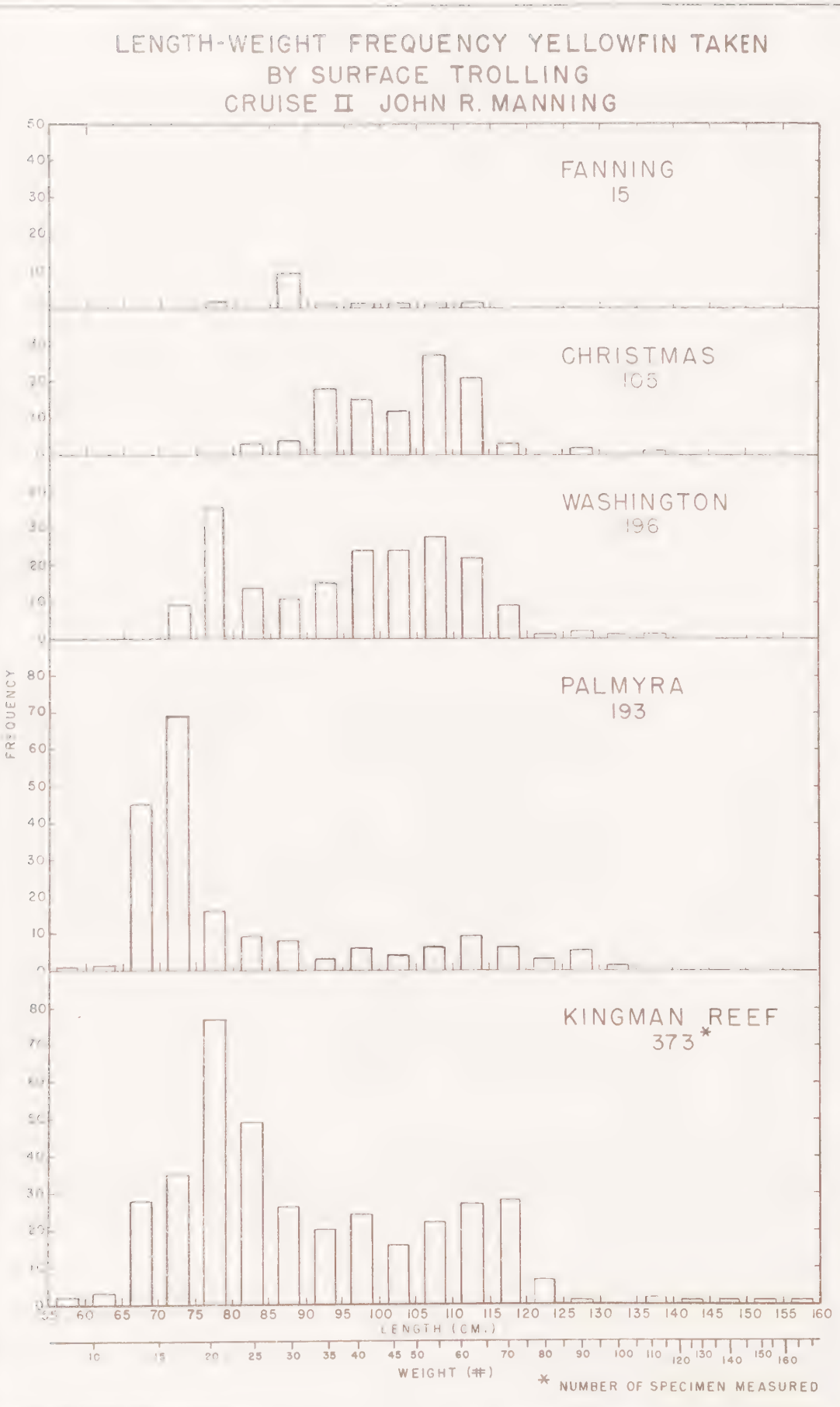

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Figure 9

DISCUSSION

Very little information on surface trolling is available with which to compare availability of Line Island tunas to this form of gear. Certain reports do contain material helpful in supplementing and evaluating the results of the MANNING's observations.

The report of the United States Fishery Mission to Peru (Fiedler et al, 1942) states that from the survey vessel PACIFIC QUEEN a total of 2,571 fish was taken by surface trolling in 476.03 hours, or 5.41 fish per hour. These fish were predominantly skipjack (Katsuwonus pelamis) followed by yellowfin (Neothunnus macropterus), with five other species constituting the remainder of the catch. No statistical breakdown of the catch is given except as indicated on charts of monthly catches, but only two of these charts are entirely legible from the microfilm reproduction available. These show the following:

Month	Hours trolled	Total No. fish	No. yellowfin	No. skipjack
April	16	394	150	209
August	19.1	455	420	25

April was the best month of fishing with 28.44 fish taken per hour as compared to May with only 2.79 fish per hour. Between 5 and 10 lines were trolled but no mention is given as to the exact number during any one period.

In comparison, the MANNING trolled 1135 marketable fish in 285½ hours or 3.98 fish per hour, yellowfin dominating the catch. As very few fish taken by the PACIFIC QUEEN were heavier than "25 kilos" in weight the MANNING's catch must have been considerably greater in poundage although less in numbers.

The PACIFIC QUEEN trolled most successfully at 5-6 knots, strain on the gear determining speed. "Surprising numbers" of skipjack were taken on standard bait pole rigs off the stern using 12' of line and barbless feather jigs, the skipjack striking even in the strongest wake and at a speed of eight knots.

A report on albacore trolling off Oregon (Powell et al, 1949) states that a white bone-type jig was most effective, particularly on rainy or cloudy days. This corresponds to results obtained by the MANNING as to yellowfin. The report further recommends a trolling speed of 6-6½ knots, also less than the speed trolled by the MANNING.

Of more specific interest are the observations of Chapman (1946). He fished Palmyra Island in early October, 1943, and reported the wahoo (ono), yellowfin, and oceanic skipjack as "abundant". He claims that surface trolling was better at Palmyra after four o'clock than at any other area personally trolled in the Pacific.

"It was customary to see skipjack off Palmyra in the later afternoon as far as the eye could see from a low vessel, the groups of small schools advancing in a crescent two or three hundred yards wide and stretching away in the distance either way....I have since talked with men back from a year and more at Palmyra and they reported that the fishing was excellent the year around whenever they could get out to sea."

His comments on surface trolling and occurrence of tunas at Midway, Johnston, and Canton Islands are similarly encouraging.

Welsh (1950) in a trolling survey of the Hawaiian Islands during the winter of 1947-48 captured 1.79 fish[1/] or 12.79 lbs., per hour of trolling. This may be compared to the MANNING's catch of 3.98 fish[1/] or approximately 124 lbs., per hour, indicating the surface trolling as being considerably better in the Line Islands. The Hawaiian survey vessel fished seven lines as compared to an average of about six lines for the MANNING (Table I).

Welsh further reports that best fishing was obtained on cloudy days and during periods of moderate to rough weather, corresponding to what was believed by the observers to be the case on the MANNING. For yellowfin tuna the Hawaii survey found plymouth rock feathers on a lead head jig to be the most effective. This type of feathers was not used by the MANNING, however. Also, the report reveals the best trolling to be on the windward sides of the Hawaiian Islands, directly opposite to the experience of the MANNING in the Line Islands, which caught all fish on the leeward sides.

Serventy (1947) in his paper on tuna trolling tests in Australia reveals that one survey vessel, WEERUTTA, during the main part of the southern bluefin season experienced the following results.

In 63 days of trolling (approx. 400 hours) in New South Wales, the tuna catch was:

Species	Number	Weight (pounds)
Southern Bluefin (*Thunnus maccoyii*)	1,042	15,690
Striped Tuna (*Katsuwonus pelamis*)	2	8
Albacore (*Thunnus germo*)	18	190

1/ Includes all marketable fish taken of which the MANNING's catch was predominantly tuna while catch in Hawaiian survey was mostly kawakawa (*Euthynnus alletteratus*) and mahimahi or dolphin (*Coryphaena hippurus*).

Thus, total tuna caught amounted to 1,063 individuals or 16,812 lbs. The WEERUTTA trolled an average of 8 lines at a speed of 8 knots. Therefore, the total tuna catch per line per hour amounted to about .33 tuna or 5.25 lbs. For yellowfin alone, the MANNING in the Line Islands averaged .51 individuals per line per hour or 16.85 pounds. The Australian catch compared favorably in numbers but lacked the poundage due to the smaller species trolled. The Australian report points out, however, that the bluefin season surveyed by the WEERUTTA in 1941 was a very poor one and "only about half as good as the peak season of 1939". In the New South Wales test, more than 100 bluefin were landed during one day on three different occasions, the largest catch being 145 bluefin in one day. This is somewhat greater than the MANNING's largest single day catch of 95 yellowfin (April 27 - Table I).

In concluding a discussion of Line Island trolling, it must be pointed out that reef and shore areas actually surveyed by the MANNING were very small. The occurrence of tunas was quite concentrated as seen in Figures 4 - 8. It is possible that these areas, unless expanded or supplemented, could not support a fishery by more than a limited number of boats. However, as previously stated, a properly built and rigged[1/] trolling vessel probably could have experienced at least double the catch of the MANNING. Of further consideration is the fact that two of the Line Islands are British-held (Washington and Fanning). Kingman Reef is designated a Naval Defense Area and was explored with permission of the U. S. Navy.

1/ By proper rigging is meant gear designed to hold tunas of 200 pounds in weight, about the maximum size that would be expected. Although these larger tunas are undesirable for cannery purposes, they must be considered if trolling gear losses are to be minimized.

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